

#### **WK4**

### **Perspectives for Nuclear Resonant Scattering and Spectroscopy with an XFEL**

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The proposed XFEL oscillator exhibits extremely attractive properties for applications of nuclear resonant scattering. The very high spectral flux of about  $10^9$  ph/s/neV paves avenues for qualitatively new experiments: Employing the nuclear lighthouse effect [1] one can operate a new type of spectrometer for inelastic x-ray spectroscopy with energy resolutions in the range of a few  $\mu\text{eV}$  and an energetic tunability of several meV. This will allow one to study a new class of emerging functional materials with low-energy excitations resulting from artificial structures on mesoscopic length scales.

Moreover, the combination of the short pulse length with a high repetition rate enables one to enter the regime of non-equilibrium lattice dynamics that can be studied via inelastic nuclear resonant scattering in pump-probe type of experiments. Related to this, a very interesting field will be the study of energy dissipation in friction processes. The understanding of friction on the nanoscale will be a key issue to improve the energy-efficiency of (micro)mechanical devices in many technological areas. The contact region of two materials in frictional contact can be very efficiently illuminated with micro- and nanofocused beams of hard x-rays. In combination with ultrathin isotopic probe layers one obtains access to dynamical processes at buried interfaces that is hardly possible with other methods.

Finally, the XFEL will open new interesting possibilities to study cooperative optical phenomena in the regime of hard x-rays. Due to the high number of more than  $10^3$  resonant photons per pulse one obtains ensembles of atoms where many nuclei are excited simultaneously. It is of fundamental interest to study the quantum optical properties of such systems. Nuclear resonant scattering allows one to study their spectral properties and temporal evolution with highest accuracy.

Nuclear resonant scattering and spectroscopy has benefited greatly from the evolution of synchrotron-based photon sources over the past decades. It can be expected that this trend will continue, especially with XFEL-type photon sources in the future [2].

1. R. Röhlsberger, T. S. Toellner, W. Sturhahn, K. W. Quast, E. E. Alp, A. Bernhard, E. Burkel, O. Leupold and E. Gerdau, Phys. Rev. Lett. **84**, 1007 (2000).
2. G. K. Shenoy and R. Röhlsberger, Hyperfine Interact. **182**, 157 (2008).